AD-A019 647

SOVIET MATERIAL ON HYDROACOUSTICS

G. Gordon, et al

Informatics, Incorporated

Prepared for:

Defense Advanced Research Projects Agency

14 January 1976

SOVIET MATERIAL ON HYDROACOUSTICS

Sponsored By

Defense Advanced
Research Projects Agency

DARPA Order No. 3097

January 14, 1976

DARPA Order No. 3097
Program Code No. P6L10, P6D10, P6E20, P6G10
Name of Contractor:
Informatics Inc.
Effective Date of Contract:
September 1, 1975
Contract Expiration Date:
January 15, 1976
Amount of Contract: $100,617

Contract No. MDA-903-76C-0099
Principal Investigator:
Stuart C. Hibben
Tel: (301) 770-3000
Program Manager:
Ruth Ness
Tel: (301) 770-3000
Short Title of Work:
"Hydroacoustics"

This research was supported by the Defense Advanced Research Projects Agency and was monitored by the Defense Supply Service - Washington, under Contract No. MDA-903-76C-0099. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either express or implied, of the Defense Advanced Research Projects Agency or the United States Government.

informatics inc
Information Systems Company
6000 Executive Boulevard
Rockville, Maryland 20852
(301) 770-3000

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Soviet Material on Hydroacoustics		5. TYPE OF REPORT & PERIOD COVERED Scientific . . . Interim 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. Gordon, M. Ness, S. Hibben, L. Poylan		8. CONTRACT OR GRANT NUMBER(s) MDA-903-76C-0099
9. PERFORMING ORGANIZATION NAME AND ADDRESS Informatics Inc. 6000 Executive Boulevard Rockville, Maryland 20852		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DARPA Order No. 3097 Program Code No. P6L10 P6D10, P6E20, P6G10
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Advance Research Projects Agency/TAO 1400 Wilson Boulevard Arlington, Virginia 22209		12. REPORT DATE January 14, 1976 13. NUMBER OF PAGES 95
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Defense Supply Service - Washington Room 1D245, Pentagon Washington, D. C. 20310		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Scientific . . . Interim

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Hydroacoustics
Sound Propagation
Acoustic Signal Detection
Sonar
ASW

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a collection of abstracts from recent Soviet publications in the field of hydroacoustics. The bulk of the material is from the proceedings of the Fifth All-Union Training Seminar in Statistical Hydroacoustics, held in Sukhumi on the Black Sea in 1973. An extended review is also include of a recent Soviet article describing in detail the organization and operation of the US/NATO submarine surveillance network. Finally, a reference list of other articles and monographs appearing in the past two years and dealing with aspects of hydroacoustics is appended.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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INTRODUCTION

This is a collection of abstracts from recent Soviet publications in the field of hydroacoustics. The bulk of the material is from the proceedings of the Fifth All-Union Training Seminar in Statistical Hydroacoustics, held in Sukhumi on the Black Sea in 1973. An extended review is also included of a recent Soviet article describing in detail the organization and operation of the US/NATO submarine surveillance network. Finally, a reference list of other articles and monographs appearing in the past two years and dealing with aspects of hydroacoustics is appended.

The proceedings of the conference in Sukhumi was selected for reporting primarily because this appears to be the largest mass of information on hydroacoustics to appear in recent times, and so presumably is indicative of the current Soviet emphasis on this subject. As the abstracts show, virtually the entire treatment is devoted to theoretical aspects of statistical signal processing, in many cases not even specifically identified with hydroacoustic signals; there is virtually no mention of experimental results or verification of the proposed theories. The enclosed abstracts are generally verbatim renditions of Russian abstracts of the conference proceedings, as they appeared in a Russian reference journal. The forty-odd abstracts included cover all but a few of the published conference papers, which were evidently omitted from the reference journal.

This volume of theoretical hydroacoustics is not typical of Soviet coverage, since a fairly steady trickle of articles routinely appears on practical aspects of hydroacoustics, as reflected in the Internal Waves reports and in the attached reference list. It would seem however to argue a high level of commitment by the Soviets to a thorough exploration of the full range of theoretical questions relating to the subject.

The article on U.S. submarine surveillance, which appeared in Morskoy Sbornik for October, 1975, is interesting of its type as an exhibit of Soviet perception of our ASW capabilities. Unfortunately no sources are cited in this article, which would be useful, particularly for the unexplained map illustrating the organization of ASW surveillance in the Atlantic.

Yeliseyevnin, V. A. Frequency correlation of fluctuations in amplitude level of a plane wave propagating in a turbulent medium in the case of strong fluctuations. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 77-81. (RZMekh, 7/75, #7B265)

Calculation is made of the cross correlation of fluctuations in the amplitude levels of two plane waves of different frequencies, propagating in a turbulent medium in the case of strong fluctuations. It is assumed that wave propagation from the emission point to the reception point follows a curved path. It is shown that in the case of strong fluctuations a saturation effect occurs for the frequency correlation of fluctuations in the amplitude level. The greater the frequency spread, the sooner the saturation point is reached.

Paderno, V. I., and I. R. Romanovskaya. Results from investigating the frequency characteristics of a multibeam hydroacoustic channel. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5) Novosibirsk, 1974, 31-35. (RZhF, 7/75, #7Zh864).

The frequency characteristics of an underwater hydroacoustic channel are calculated for two cases of signal summing during multibeam propagation: (a) during non-correlation of the beams; and (b) during summing, allowing for the phase of the fluctuations. Three cases of different hydrologic states of the medium are examined: (a) continuous acoustic exposure; (b) an underwater acoustic channel at a depth of 1000 m; (c) an underwater acoustic channel at a depth of 100 m. Results are given for calculations of cases of 18- and 4-beam propagation and, correspondingly, 250 and 35 msec maximal delay time, as well as the results of calculations for different propagation distances.

Gulin, E. P. Characteristics of modulated signals propagating in media with random parameters. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 51-60. (RZhF, 7/75, #7Zh880)

The causes are examined for changes in the modulation level of acoustic signals propagating in a single-beam channel during reflection from a random, inhomogeneous boundary of two media, and during propagation in a multibeam channel with fluctuating lag times in individual beams. The autocorrelation function and energy spectrum of the modulated signals are calculated. Evaluation are made of the reciprocal correlation of the modulated signal and the envelope at the modulation frequency, as well as the mean value of the envelope at the modulation frequency.

Antonov, V. P., T. A. Moroz, and V. V. Ol'shevskiy. Results and problems from investigating statistical characteristics of ocean reverberation. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 87-106. (RZhF, 7/75, #7Zh868).

Principal approaches and problems in investigating the statistical characteristics of ocean reverberation are examined. At present three lines of investigation of ocean reverberation are being pursued: the development of mathematical models, experimental studies, and the modeling of reverberation processes. One of the principal problems in experimental studies of the nature of reverberation is the establishment of quantitative measures of the adequacy of one or another reverberation models, based on experimentally obtained statistical assessments. The first period of experimental studies of the statistical properties of reverberation, which ended in the early 1960's, is characterized by the use of analog means for storing and processing experimental data, and by the application of time averaging of sampled data. The second period is characterized by the use of discrete means of storing and processing experimental data and the use in averaging of sampled sets of reverberation data.

The principal tasks of the experimental studies have been the investigation of the non-stationary properties of reverberation and of certain characteristics of its quadrature components, envelope and slow phase. The experiment results show that the hypothesis of the normality of the distribution of quadrature components is confirmed for all time instances during the observation interval, when the coefficient of asymmetry of the excess is used as a criterion. The time intervals are determined for the span within which the slow phase of reverberation is stationary.

Ovchinnikov, V. P., V. I. Pakhomkin, V. P. Ryzhov, and K. V. Filatov. Experimental investigation of spectral characteristics of reverberation in the sea, following generation of complex signals. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 157-161. (RZhF, 7/75, #7Zh869).

Results are described of experimental data obtained in studying the spectral characteristics of instantaneous values of sea reverberation (R) and its instantaneous frequency (F) for the pulsed emission of signals with linear FM, symmetric (V-form) linear FM and zig-zag linear FM in the region of a 100 m deep sea having a level floor. The signal duration was 10, 30, and 100 msec; the frequency deviation values were 1, 2 and 5 kHz. The reverberation processes were recorded at acoustic system slope angles from 2 to 30°. Spectral analysis was made of the recordings obtained for reverberation processes using a device containing a time selector, frequency converter, and parallel 8-channel spectrum analyzer.

The principal parameters of the sound-generating, sound-recording and analyzing device are cited, as well as basic formulas for assessing the spectral density of dispersion. For each type of signal a correlation was obtained between the energy spectrum and the instantaneous frequency spectrum for bottom, spatial, and surface reverberation. The reverberation energy spectra for signals with a frequency deviation of 1 and 2 kHz are close

to the corresponding spectra for probe signals, but differ from those for signals with a deviation of 5 kHz. The determinacy of phase relationships intrinsic to the probe signal is not reflected in the spectrum for instantaneous frequency reverberation. Moreover, the width of the instantaneous frequency reverberation spectrum does not depend on the type of frequency modulation of the emitted signal, and is determined by the latter's frequency deviation.

Furduyev, A. V., and S. D. Chuprov. Characteristics of noise field sources in the ocean. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 195-202. (RZhF, 7/75, #7Zh870).

Based on available experimental data, principal characteristics of noise field sources in the ocean are described. Among these are: localization of noise sources at the ocean surface; fine structure of sources at the surface and their low (in comparison with wavelength) spatial correlation; and a one-to-one relationship between the diagram of emission directivity for each of the sources. In most practical cases the spectrum of the received noise corresponds to the spectrum of the sources.

Yemel'yanenko, I. V., Ye. B. Libenson, and A. F. Paliy. Characteristics of reverberation interference at the output of a matched filter. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 275-277. (RZhF, 7/75, #7Zh871).

The relationship was studied between levels of correlated and non-correlated reverberation components at the output of a matched filter, as a function of the bandwidth of the probe signal, this being a rectangular

pulse having a duration of τ = 1 sec with pseudo-noise complement. Analysis of the correlograms showed that the output relationship of the correlated reverberation components to the non-correlated components for signals with a bandwidth of Δf = 30 Hz is 12-14 db, while for a Δf = 220 Hz, it is 14-18 db. When there is a broad band the response signal from the sea floor is resolved in time as the reflection from a series of points. If the band is narrow, the same reverberation responses are not resolved, but the total output signal of the correlator is more extended due to reflector interference.

Ol'shevskiy, V. V., and S. L. Pivovarov. Signal recovery against a background of noise and reverberation interference, using square-law detection. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 278-288. (RZhF, 7/75, #7Zh872).

The parameters of an emitted [sonic] signal were analyzed using characteristics of echo signal detection against a background of noise and reverberation interference. The case is examined of signal emission in the form of a segment of a Gaussian stationary random process, and a formula is obtained for the characteristics of echo-signal detection for this case. Further analysis of the effect of emitted signal parameters on the output characteristics of the system is done by standardizing the parameters of the signals, namely the relative width of signal spectrum α_s and the relative duration of the signal β_s. Two cases are examined of radiation which is expressed in terms of a constant energy level and constant power amplitude of the emitted signal. From the detection characteristics for these emission regimes, equations are obtained for echo-signal/noise threshold relationships Q_{sn} which are an important detection characteristic. Examination is made of the Q_{sn} as a function of α_s and β_s at different reverberation levels against a noise background. It is shown that, if the emitted signals of different types are then examined as a segment of Gaussian noise, the results will be analogous, although possibly they may be expressed in a different quantitative relationship.

Kopyl, Ye. A. Sound scattering by the ocean surface at small glancing angles. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 107. (RZhF, 7/75, #7Zh875).

Assessments are made of the index of sound scattering by the ocean surface in directions which are close to the direction of mirror reflection from a mean surface. The Kirchhoff method was used in a short-wave approximation allowing for shadow. It is assumed that the surface is isotropic and has a normal distribution of heights and slopes. The mean square-law angles of surface slope are $\delta = 4^{\circ} - 10^{\circ}$. Computer calculation shows that the difference between the glancing angle $\varkappa_0$, which corresponds to the scattering index maximum, and the glancing angle of wave $\varkappa$ falling on the surface may reach several degrees, even if the slope angles of surface roughness are moderate. If angle $\varkappa$ is increased, the direction of the predominant scattering approximates mirror scattering; the lower the value of δ, the greater is this tendency, for $\varkappa \to 0$, $\Delta\varkappa = \varkappa_0 \to \varkappa$ also tends to zero, which corresponds to the propagation of an acoustic wave along the surface. It is noted that these phenomena can exert a significant effect on the nature of sound propagation in a surface layer channel.

Dragan, Ya. P., and I. N. Yavorskiy. Distortion of hydroacoustic signals on their reflection from a sea surface. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk. 1974, 111-112. (RZhF, 7/75, #7Zh876).

During the propagation of sinusoidal fluctuations in a surface layer underwater acoustic channel, frequency modulation and amplitude modulation of the fluctuations occur due to scattering from the sea surface. The statistical characteristics of such a signal can be found in solving the

problem of the diffraction of a monochromatic wave on an uneven surface. On the basis of the sound scattering model proposed by Parkinson [RZh Fiz, 1968, 6Zh549], an analytic formula is obtained for the mean value and the correlation function of a signal scattered by slight surface irregularities. It is shown that the signal obtained as a result of the scattering of a sinusoidal wave by the sea surface can be described by a periodically correlated random process, in which the correlation function of its stationary approximation equals the effective part of the signal's correlation function.

Klyachkin, V. I. Functional methods in statistical hydroacoustics. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 3-25. (RZhF, 7/75, #7Zh878).

Application of a method of characteristic functionals to the analysis of the stochastic structure of random processes and fields in hydroacoustics is examined. The relations determining the correlation between real random fields and the sources generating these fields are analyzed. The problem of defining the structure of a field according to the given stochastic structure of the source field (direct problem) and the problem of defining the source field according to the given structure of the random field (inverse problem) are examined. The apparatus developed is used to describe the statistical structure of pressure pulsations in a turbulent flow, and to analyze the distribution of a random signal across a randomly inhomogeneous sea waveguide. The author notes that the cited methods permit a generalization to dynamic systems of a type of generalized multiplier and correlator, and can also be used in the analysis of inverse problems in statistical reverberation theory.

Novikov, A. K. Synthesis of an a posteriori model of a random process, using statistical characteristics of one sample function. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 26-30. (RZhF, 7/75, #7Zh879).

The synthesis is examined of a model of a random process based on measurement of noise parameters emitted by a system. The results are determined to a considerable degree by the a priori hypothesis adopted as to the nature of the distribution phase of the assumed process. Based on an analysis of calculations for the characteristics of multiplicative and additive processes, the author shows that the properties of the modulated process are determined by the modulation coefficient and by the spectra of the supporting and modulating functions.

The author notes that a model having the form of a modulated process should include information on the initial phase, and that this model reflects the deviation of the process both from the steady state as well as from the normal process.

Gulin, E. P. Spectrum of pulsed signals in a multibeam channel. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidrokustike (SG-5). Novosibirsk, 1974, 61-72. (RZhF, 7/75, #7Zh865).

Problems in calculating the spectrum of pulsed signals in a multibeam hydroacoustic channel having constant parameters are examined. An assessment is made of the energy spectrum of pulsed signals, given the

existence of an irregular sporadic component of relative motion of emitter and detector, and of fluctuations of the signal from individual beams.

Malyshev, K. I. Effect of frequency dependence of spatial sound attenuation on correlated reception of wide-band signals. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 73-76. (RZhF, 7/75, #7Zh881).

Relationships are obtained which allow an approximate evaluation of the operational quality of a cross-correlation receiver in those cases where the reference signal does not coincide with the signal being received. During this type of reception the detection index is primarily determined by the cross-correlation of the received and the reference signals, which is dependent on sound wave propagation conditions in the ocean. Relationships are obtained which determine the value for the cross-correlation coefficient at frequencies corresponding to optimal propagation conditions. Results are cited of quantitative calculations done for cases in which target strength does not depend on frequency.

Kudryashov, V. M. Acoustic fields in a waveguide with a statistically uneven surface. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 36-50. (RZhF, 7/75, #7Zh874).

A review is given of research on scattering on a wavy sea surface of acoustic waves propagating through a near-surface waveguide with

an acoustically soft upper boundary. The acoustic field in the waveguide is analyzed, assuming that it can be represented as a sum of coherent and random components; the random component generates only small disturbances in the main coherent field. These assumptions make it possible to approximate the upper boundary of the waveguide with a plane surface, as well as the coherent field with superposition of normal waves corresponding to zero acoustic pressure at that surface. The random component is determined using the law of conservation of energy flux. Results are given of computer-aided calculations of the average intensity and correlation function for the random component.

Shmelev, A. B. The average Umov-Poynting vector for an acoustic field under conditions of scattering at a rough surface. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 82-86. (RZhF, 7/75, #7Zh748).

The average vector of the energy flux during scattering of spherical acoustic waves on an infinite rough surface is calculated. Irradiation by a nondirectional point source and by an acoustic dipole is considered. General expressions for the vector components, as well as their asymptotic forms, are given. The relation of vector component magnitude to the direction of the scattered emission vector is analyzed for different values of those parameters which define the degree of surface roughness.

Grachev, N. N. Wave scattering at a statistically rough curvilinear surface in the near zone. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 108-110. (RZhF, 7/75, #7Zh749).

Energy characteristics of a scattered field are determined, using expressions for pressure in waves scattered by a curvilinear statistically rough surface. The expressions are determined from Kirchhoff's approximation for the case of a separated source and receiver, using the tangential plane method. The effect of the finiteness of the scattering surface on the amplitude of the scattered waves is estimated. The roughness of the scattering surface is assumed to be characterized by a normal distribution law. The effect of the directional pattern width on the r.m.s. value of the equivalent radius of curvature of the surface, under conditions of reflecting and scattering, is considered. It is noted that the obtained expressions can be used in modelling the structure of echo signals.

Kovtunenko, S. V., E. A. Levin, V. A. Saprykin, and N. I. Cherepkov. The problem of representing hydroacoustic signals. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 116-119. (RZhF, 7/75, #7Zh832).

Assuming that functions describing hydroacoustic signals are defined along the infinite line $-\infty < t < \infty$, the authors represent hydroacoustic signals in terms of groups of linear transforms of the real line. The representation allows for a finite propagation velocity, Doppler change of time scale due to motion of emitter and receiver, and inhomogeneity of the medium. Two types of representation in the form of spatial operators are obtained. Two classes of signals are considered: analytical signals, and signals obtained by means of Mellin transform. In the latter case, the hydroacoustic signals are represented in the form of a convolution-type operator.

Taradanov, L. Ya. Correlational properties of echo signals. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 129-136. (RZhF, 7/75, #7Zh883).

The relationship between autocorrelation and correlation functions of sounding and echo signals are analyzed, assuming that the scattering index for the reflecting object is known. Calculations are performed for pulsed sounding signals and reflecting objects of the circular disc and finite cylinder type, under the condition that the spectra of the emitted pulses have a rectangular shape. The results can be used in designing a receiving channel of a correlator, since many real objects can be approximated by a set of discs and finite cylinders.

Kaptyug, A. A. Adaptive procedures for obtaining the efficiency index of a measuring system. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 351-355. (RZhF, 7/75, #7Zh904).

An adaptive procedure is considered for obtaining an index of effectiveness of a complex measuring system providing real-time information. "Machine" interpretation of the system is included in the concept. The analysis is based on the fact that the efficiency index corrects itself with accumulation of information; the question is one of formalizing the expressions for correction rules. From the analysis, with some informal assumptions, it is concluded that in the case of complex systems there is advantage in accumulating data on its parameters prior to its operation. In this case the information must be compact and invariant with respect to type of measuring system. The adaptive simplification in system description will be more effective with lower loss of useful information input, as well as with increased compactness and invariance in this information.

Kaptyug, A. A. Axiomatics for an adaptive procedure to obtain the efficiency index of measuring systems. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 356-366. (RZhF, 7/75, #7Zh905).

The description of any problem is proposed in the form of elementary problems, on the assumption that algorithms of elementary problems will generate an algorithm for the overall problem. Various axiomatic constructions of an effectiveness index are considered for the simplest situation, on the basis of which the structure of an overall efficiency index can be found. The algorithm discussed is applicable to problems of hydroacoustic data processing.

Galybin, N. N. Determination of the high-frequency portion of a spatial ocean wave spectrum by means of deep-water explosions. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 208-210. (RZhF, 7/75, #7Zh750).

The results are described of spectral studies of sea waves by remote acoustic methods, using deep-water explosions as sound sources. Expressions for the calculations of the back-scattering index are obtained, on the basis of a resonant theory of acoustic scattering at the sea surface, at frequencies of 1, 2, 5, 10, and 20 kHz and wind velocities of 9.5 and 4.5 m/sec. An analysis of the averaged sea wave spectra, and comparison with spectra reported by Kingsman, Phillips and Leykin, shows that deviation from the values of 90%-confidence interval does not exceed $\pm$ 3 db.

Artemenko, E. A. Accuracy of measuring certain random characteristics of hydroacoustic fields. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 203-207. (RZhF, 7/75, #7Zh848).

A discussion is given of errors in measurement of the spatial characteristics of the unidirectional, axisymmetric [sonic] field of a finite surface source with nonuniformly distributed intensities of oscillations within a "noise patch". The spatial correlation function at low frequencies is measured by an array in the form of two horizontal and one vertical line of hydrophones. The characteristic curve of the field is measured with a set of spherical hydrophones arrayed in the form of a flat piston. An analysis is made of systematic and random errors in the measurement of the correlation function and the characteristic curve of the field, in terms of r.m.s. error.

Karlik, Ya. S., A. P. Kovalev, and V. V. Semenov. Study of interference-free antennae of the plane phased array type for reception of a multibeam signal under conditions of anisotropic interference. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 261-267. (RZhF, 7/75, #7Zh852).

Efficiency of planar phased arrays in the presence of anisotropic noise is considered. The useful signal at the point of reception is represented in the form of a superposition of several waves (or beams). It is assumed that all transmitted beams are in the same vertical surface and that within the aperture, each beam represents a plane wave. The source of anisotropic noise is a noise-emitting plane consisting of a set of elementary sources, which have directivity patterns in the form $R(\varphi) = \cos^n\varphi$ ($n = 1, 2, 3$), where

φ is the angle with the normal to the noise-emitting plane . The system is directed so that the normal to the array surface is horizontal. Expressions for noise rejection of a planar phased array at an arbitrary scanning angle are obtained. In order to analyze the effect of the multibeam nature of the signal, and of the noise anisotropy, a quantitative analysis has been made for many variants of arrays and propagation regimes which are of practical interest.

Gubarev, V. V., and G. N. Khusnutdinov. Use of computer modelling in the theory and application of statistical data processing and statistical measurement. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 137-143. (RZhF, 7/75, #7Zh884).

A theoretical study of computer modelling in statistical echo sounding is reported, and some practical aspects of modelling in statistical hydroacoustics are discussed. Advantages of computer modelling in the analysis and synthesis of algorithms for approximating characteristics of a random process are demonstrated. Modelling is also useful when applied to the instrumental analysis of random processes, providing a means for analyzing instrumental error and optimal circuits for analyzers. Modelling possibilities in establishing accuracy criteria, determining approximation algorithms, testing analyzers, and constructing master curves for instrumental error estimation are considered. Accuracy criteria for statistical modelling are also examined.

Libenson, Ye. B. Evaluating the indeterminacy function of wideband FM signals. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 152-156. (RZhF, 7/75, #7Zh885).

A modification is proposed to the method for evaluation of the indeterminacy function of wideband FM signals, which is based on the principle of stationary phase. The modified method allows for time scale variations caused by Doppler effects, and is based on expansion of the modulation function into a Taylor series at the point of stationary phase. An expression is obtained which is defined as a "tolerance degree" of a signal with regard to Doppler effect. It determines the dependence of the level of the indeterminacy function of an FM signal of a general form on the Doppler rate. With use of the Doppler tolerance degree, the dependence of the main lobe parameters of the ambiguity function on signal structure can be measured. Specific types of modulation are discussed, including hyperbolic FM which is Doppler invariant, and n-th degree FM.

Bogotov, V. K., I. I. Mironov, and S. M. Perevertkin. Preliminary analysis of the statistical properties of random nonstationary processes. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 144-147. (RZhF, 7/75, #7Zh886).

A structural scheme is presented for automatic processing of data from nonstationary processes, with the object of determining the characteristics of an object or set of objects. Data processing is performed in three stages; in the first stage, dimensionless values are converted into physical dimensions of the analyzed process. In the second stage, the

reliability of the measured values is evaluated, the dynamic distortion of sensors and matching devices are compensated, limits of stationary intervals are determined, and nonstationary data are reduced to stationary ones. In the final stage, characteristics of the test object are determined. The proposed scheme and techniques on which it is based can be realized with uniform algorithms, and an optimal solution using the Neyman-Pierson criterion can be obtained.

Kamarov, V. A., and V. P. Semenov. Rational distribution of transmission energy among spaced channels in binary non-redundant information coding. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 172-173. (RZhF, 7/75, #7Zh889).

An N-position binary information coding system is considered. The particular case is treated in which commands are represented in the form of a binary code, with individual bits being transmitted through discrete channels. Relations are obtained which define the optimal transmission energy distribution over channels so as to minimize the errors of total energy decoding in the presence of reverberations.

Godziashvili, Yu. G., and G. I. Usoskin. Effect of parameters of a multichannel measuring system on noise-field intensity, averaged in space. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 174-178. (RZhF, 7/75, #7Zh890).

A theoretical study is presented on spatial averaging of statistical characteristics of noise fields within a multichannel system.

The effect is evaluated of random amplitude and phase dispersions in parameters of the acoustic system on the measured accuracy of average noise intensity. An expression is obtained for the relative shift of spectral density at the output of an adder, fed by signals from uniformly spaced elements of an acoustic array; the expression is valid for an arbitrarily structured noise field.

It is shown that in the case of uncorrelated input processes, the relative shift at the adder output is the same as at the output of a single channel, and is independent of phase dispersion. In the case of correlated input processes, the relative shift at the adder output is smaller by a factor of N (N = number of channels) than that at the output of a single channel. A numerical analysis is given of the dependence of normalized relative shift of spectral density on wave distance between elements of an array, for the case of an isotropic noise field.

Gatkin, N. G., L. N. Kovalenko, and L. G. Krasnyy. Adaptive detection of signals with unknown parameters. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 245-249. (RZhF, 7/75, #7Zh895).

Adaptive signal detection using a two-stage receiver is considered. It is shown that resolution and accuracy of measurement of signal parameters are increased by adaptive detection. Noise rejection of an adaptive receiver is higher than that of a multichannel receiver, but is 4 db lower than that of an optimal receiver, owing to a priori uncertainty of duration and frequency.

Perov, V. P., and M. B. Solodovnichenko. Stationary filtering of nonstationary processes. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 191-192. (RZhF, 7/75, #7Zh891).

The problem of synthesizing optimal stationary filters on the basis of orthogonal filters is considered. In many cases such filters can be used in statistical filtering of hydroacoustic signals.

Bozhok, Yu. D., N. G. Gatkin, L. G. Krasnyy, and S. V. Pasechnyy. Quasioptimal method of signal detection in a multicomponent interference field. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 250-255. (RZhF, 7/75, #37Zh896).

Optimal detection is considered of echo signals from two discrete arrays, each of them performing non-optimal spectral processing in the form of unweighted summation. Optimal processing of echo signals from the output of two arrays significantly enhances the efficiency of the receiving channel in the presence of sufficiently strong local noise sources. The correlation between outputs of two arrays is considered, where the arrays are located in a uniform stationary field and the signals from each array are detectible spatial and time parameters.

Calculations of noise rejection are performed for a model representing superposition of uncorrelated isotropic and anisotropic noise fields. The results show that for signal detection in the presence of a multicomponent noise field, optimization of the receiving channel, given the method of spatial processing in each array, can be achieved.

Nakhmanson, G. S. Accuracy of estimating signal paramcters against the background of reverberation and correlation interferences. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 308-310. (RZhF, 7/75, #7Zh901).

An evaluation is made of arbitrary nonenergy parameters of signals with random initial phase, uniformly distributed over the $0-2\pi$ range, and with random amplitude having a Rayleigh distribution. The evaluation is made by means of a nonoptical receiver with a background of normal correlated noise and reverberations. The suggested method is also valid for evaluating energy parameters of signals. However, in this case the evaluation is biased and the final expressions are all complex, i.e. the useful component and noise correlation functions at the output of the receiver are not symmetric. The arrival time of a signal in a background of white noise plus reverberation is evaluated as an example.

Gerasimenko, O. N., V. P. Ovsyanik, and S. V. Pasechnyy. Determining parameters of nonstationary random processes in the presence of pulse interference. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 256-260. (RZhF, 7/75, #7Zh897).

Possible modifications are considered of an algorithm for classification of random processes as to their stationarity in the presence of chaotic noise. The stationary/nonstationary determination is made by measuring a discrimination factor of amplitude nonstationarity in comparing characteristics of the random process in question and a reference Gaussian stationary random process. The results of the study show that the proposed method is reasonably effective in the case of pulsed noise.

Krukovskiy-Sinevich, K. B. Quasioptimal reception of slowly fluctuating echo signals averaged in velocity. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 289-294. (RZhF, 7/75, #7Zh899).

The possibility of synthetizing an optimal receiver, as defined by the Bayes criterion, is considered for a slowly fluctuating signal and Gaussian noise in the case of an a priori unknown target speed. An algorithm is presented for an optimal receiver with velocity averaging. The synthesis of such a receiver is hindered by the necessity of developing an infinite number of squaring-correlation channels which are optimized for different target speeds, and by the corresponding complex nonlinear transforms of the exp x^2 type.

A synthesis method is proposed which eliminates multichannels and complex nonlinear transforms. It is shown that under certain restrictions, a receiver with velocity averaging can be realized according to a single-channel scheme: linear filter-square law generator - averaging LΓ filter. However, the single-channel scheme is not applicable in the case of a mixture of white noise and reverberations. In the case when $\Delta F_D T = 3$ (ΔF is Doppler frequency band; T = duration of sounding signal), the quasioptimal filter compares favorably to the optimal as regards noise rejection. It is noted that the cited results cannot be considered as the ultimate, since cases of small probability of false alarm and of $\Delta F_D T > 3$ have not been considered.

Zayezdnyy, A. M. Metrological principles of hydroacoustic information processing according to its structural properties. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 330-350. (RZhF, 7/75, #7Zh903).

A review is presented of the present state-of-the-art in diagnosis and classification of processes based on their images. The formulation

of the problem is reduced to classification of a system of realizations of a random process, and to synthesis of measurement algorithms which yield high reliability in the case of small a priori information on noise. The solution of the problem is accomplished using structural characteristics, i.e. image characteristics. Distribution laws of images obtained from known distributions of initial processes, using general equations of probability theory, are considered. A classification of quasirandom and random processes is made, and algorithms for uncorrelated evaluation are synthesized. Algorithms thus obtained are optimized for the case of fluctuating noise. The author notes that algorithms based on structural characteristics can be realized in both analog and digital forms. An experiment with visual classification of a random process on the basis of structural characteristics is performed, using a phasoscope set (oscillograph-phasoscopes with different phase coordinates).

Balagin, V. V., and B. P. Brezhnev. Separation of useful hydroacoustic echo signals by a computer using fast algorithms. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 302-307. (RZhF, 7/75, #7Zh900).

The problem of computer-aided extraction of the useful portion of a received signal is considered, for the case of horizontal radiation from an above-water object with a fixed sonar platform. It is assumed that in the case of rectangular audio sounding pulses with a given length and frequency, the correlation functions of the signals are known and the signal-to-noise ratio is reasonably high. One of the extraction algorithms is described and signal parameters are evaluated. Expressions are obtained for probabilities of the correct detection of signal arrival time, of false detection, and of mean delay in detection of signal termination. Numerical calculations by a Minsk-22 computer have been made of parameters which optimize the detection of signal arrival time and minimize the delay in detection of the signal termination, given a preset probability of false detection. The cited algorithm achieves a reduction in time of computer-aided signal recovery.

Antoshin, V. A., and N. A. Rubichev. Estimating the effect of nonstationary hydroacoustic signals on errors in measuring their one-dimensional distribution laws. Trudy Pyatoy Vsesoyuznoy shkoly-seminara p› statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 193-194. (RZhF, 7/75, #7Zh892).

An approach is considered which would provide an evaluation of nonstationarity of random hydroacoustic signals, as this would affect measurement error in the analyzers. One-dimensional and, with some generalization, multidimensional distribution laws for these signals are treated.

Petrov, V. V. Methods of Kalman filtering (review). Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 211-230. (RZhF, 7/75, #7Zh893).

The problem of filtering a random vector function is formulated. A dynamic model of a Kalman-Busse filter is described, in which the signal is represented as a vector of a linear system which is excited by Gaussian white noise. It is shown that the problem reduces to solving a Riccati matrix differential equation. Several signal models are considered, such as an n-th order Markovian process; a stationary random process with a discontinuous spectrum; quasideterminate; and amplitude-modulated signals. An interpretation of the Kalman filter is given in the form of a tracking system, and some factors are considered in the solution of the Riccati equation. The basic scheme is generalized for the case of correlated non-white noise. Methods for approximation of a posteriori distribution and for developing filtering equations are described.

Krasnyy, L. G. Principles of optimal adaptation in processing hydroacoustic information. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 231-244. (RZhF, 7/75, #7Zh894).

Synthesis of adaptive detectors is considered, assuming that sensing is divided into n intervals of duration T. An adaptive detection algorithm with self-correction is obtained, for the case in which the probability characteristics of the noise are unknown, and a signal of known length T occurs only in the last observational interval. In general, for synthesis of an optimal algorithm it is necessary to reconstruct a posteriori the noise distribution. However, in case of a long correction interval, a maximum estimate of the probabilities of the unknown noise parameters can be used.

Assuming that the probability characteristics of the signal and noise are unknown, the author examines algorithms for detection in the case of active correction. In this case, the signal is assumed to occur in any interval. It is shown that the optimal algorithm reduces to the Bayes estimate of probability ratio. Stricter correction algorithms are considered as well, and examples of optimal adaptive detection systems, e.g. adaptive filters for determinate signal detection, and adaptive antenna arrays, are given.

Gol'dman, R. S., and M. S. Titov. Diagnosing and classification of marine objects by use of test theory. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statistichiskoy gidroakustike (SG-5). Novosibirsk, 1974, 311-315. (RZhF, 7/75, #7Zh902).

The problem of designing automatic devices for diagnosis and classification of marine objects from echo signals is considered, based on test theory. The main stage in design is the selection and analysis of a set of

identifying indicators. An experiment using the Minsk-22 computer has shown that indicators can be divided into several groups, depending on their degree of significance; these are listed as primary, secondary, etc. Fourteeen indicators have been calculated for echo signals from three targets of the same class (ship, whale, school of fish). In the calculations, structured signal models were used along with contour types. Indicators obtained using structural signal models were shown to have a relatively high diagnostic significance. Steps in writingthe program are discussed.

Danilova, Ye. A., and V. V. Ol'shevskiy.
Correlation processing of echo signals with a random spectral mid-frequency, allowing for interferences of noise and reverberation.
Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 268-274. (RZhF, 7/75, #7Zh898).

An analysis is made of the quality dependence of a hydroacoustic system on several signal parameters. These include the relative frequency of echo signals as determined by Doppler shift; the complexity factor, determined by the product of the effective duration and effective bandwidth of the signal; and the average reverberation-to-noise ratio. With the relative frequency assumed to be random, three types of distributions are considered: one satisfying an inverse sine law, a uniform normal distribution, and a truncated normal distribution. Computer-aided calculations for pulsed FM signals with bell-shaped envelopes show that the signal-to-noise ratio has a minimum which is characterized by the lowest coefficient of complexity of the transmitted signals, and which depends on reverberation-to-noise ratio and upon the range of the relative frequency deviations.

Antoshin, V. A., and S. V. Kropotov. Error estimation of the spectrum analyzer of a filter of hydroacoustic signals. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibirsk, 1974, 162-165. (RZhF, 7/75, #7Zh888).

Two methods (by sets and by elements) of quantitative evaluation of r.m.s. error r(f) in a filtered analyzer are discussed. The treatment is based on a block diagram of random hydroacoustic signals $\{x(t)\}$, which is proposed by the authors. The methods are subject to the following restrictions: 1) all elements of the analyzer are decoupled; 2) the process analyzed represents an additive mixture of independent cosines with random uniformly distributed phases; and 3) the set of analyzed signals $\{x(t)\}$ is characterized by fixed variation ranges for all parameters. Quantitative estimates by sets is suitable for testing spectrum analyzers; however, estimate by element is more suitable for fabrication and failure diagnosis of spectrum analyzers. The essence of the latter method is that total error is found from errors of individual elements. Diagrams are given for a spectrum analyzer consisting of single resonant circuit, square-law detector, and low frequency filter.

Bespalov, L. A., A. M. Derzhavin, O. L. Sokolov, and V. A. Kuz'min. Rational selection of criteria for investigating the inhomogeneity of noise fields according to dispersion. Trudy Pyatoy Vsesoyuznoy shkoly-seminara po statisticheskoy gidroakustike (SG-5). Novosibrisk, 1974, 148-151. (RZhF, 7/75, #7Zh887).

Functional schemes are given of devices for identifying the nonuniformity of a noise field, which use spatial dispersion or F_{max} as criteria. For the F_{max} criterion, the ratio of the maximum noise intensity

in all directions to the minimum is used as a statistical test. It is concluded that the spatial dispersion criterion is the more powerful one; however it has a first-order error which is independent of noise intensity in selected directions. The F_{max} criterion serves as a rapid test for inhomogeneity of multiple dispersions. In order to enhance the power of the F_{max} criterion, which drops with increase of the number of averaging directions, and to decrease errors due to averaging time and nonstationarity type, the authors suggest to use $\ln F_{max}$ instead. This criterion is invariant under dispersion transformation.

Soviet Assessment of U.S. and NATO ASW Capabilities

The October issue of the Soviet Navy journal Morskoy Sbornik contains an article* on the ASW systems, technology, and capabilities of the US and NATO forces. The article is based on non-Soviet references, although none are cited. The following is an extensive extract of the article.

The most difficult and important aspect of ASW is considered to be the initial detection of an underwater target; therefore, non-Soviet nations are paying exceptional attention to the development of detection systems.

The necessity for precise information on every nuclear submarine is dictated by the fact that some of them carry strategic weapons, which would call for their immediate destruction at the outbreak of hostilities. For example, reconnaissance satellites keep track of ship disposition in ports. There is constant monitoring of communication and radar signals, including super-high-speed transmissions. Radar and TV systems play a lesser role in detection, since nuclear subs rarely surface. Magnetic detectors, infrared equipment, and laser systems are also used; however, their short detection range and low resolution make them at present inadequate.

Although reconnaissance satellites are very effective in detecting subs in bases, they are ineffective in sub detection at great depth. According to a NASA representative, by the end of the 1960's, multispectrum instruments with resolution to 9 meters were capable of detecting underwater objects to depths of 60 meters. The non-Soviet press reports that photography in the IR and visible spectra with subsequent photo comparison will facilitate sub detection at great depths. If we consider that high-speed transmission of photographic data from a satellite to ground will soon be possible, then the ASW potentials offered by reconnaissance satellites will be greatly increased.

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* Chizhov, B. SOSUS detects a sub. Morskoy sbornik, no. 10, 1975, 93-97.

At present, detection of a sub in the ocean is generally by acoustic means. The Americans consider that these systems have substantial shortcomings, the principal of which is the high sensitivity to hydrological conditions of the water. Many non-Soviet specialists also think that the effectiveness of hydroacoustic systems can be reduced significantly or completely neutralized by ECM. Nevertheless, hydroacoustics remains the basic detection method now and for the foreseeable future.

Passive and active sonars are classed as mobile and fixed. Mobile sonars are installed in aircraft, helicopters, surface ships, and submarines. Since their range is relatively limited, the main responsibility for long-range detection and primary target classification falls to fixed systems (see Fig. 1). Applying only these systems, the command of the US and NATO naval forces plans to develop very extensive detection lines and zones in ocean theaters of military operation.

Fixed systems are installed based on the military geographic features of the ocean area. In the Atlantic, for example, the natural narrows (straits) are covered. The most important of these are considered to be the passages between Bear Island and the northern cost of Norway, between Greenland and Iceland, between Iceland and the southwestern coast of Norway, between Newfoundland and the Azores, and between the Azores and the southwestern coast of Spain, as well as the Straits of Dover and Gibraltar. Hydrophone units are placed on the continental shelf, ridges, and rises to provide the broadest observation zones.

The rapid development of the Caesar system in a relatively short time has made it possible for the [naval] command to develop a permanent detection system (SOSUS - Sound Surveillance Underwater System) for the Atlantic and Pacific.

This system is involved in the collection and technical analysis of information on all acoustic contacts. To forecast weather and ocean conditions and obtain data on their actual state, the ASWEPS system is used.

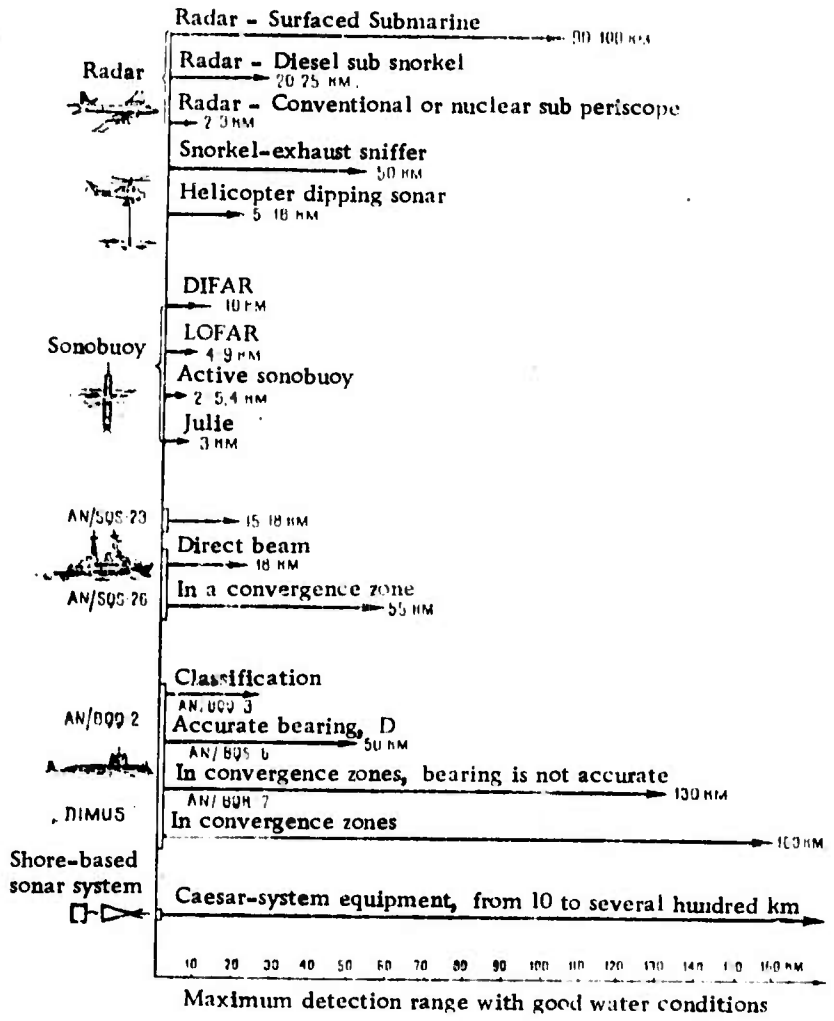

Fig. 1. Potential Submarine Detection Ranges for ASW Forces.

After target detection by SOSUS, a mobile unit (usually an ASW patrol aircraft) is dispatched to the detection area to further pinpoint and classify the contact. A sub is then tracked continuously.

The US and its NATO partners are involved in establishing detection zones and lines in the Atlantic. For example, the British Navy conducts observations in the Straits of Dover and Gibraltar; the Canadian Navy has responsibility for its Atlantic coast, the Arctic Basin, and an area of the Lincoln Sea. NATO land-based aircraft, surface ships, and subs perform ASW reconnaissance and report contacts to their respective national command centers.

The NATO navies exchange information on sub contacts. Special maps reflecting these contacts in the Atlantic and Pacific are prepared by the US Navy. Thus, in the US and partly within the framework of NATO, an integrated system is developing for collecting, processing, analyzing, and visualizing subsurface activities, and for providing this information to naval forces in the major ocean areas. Non-Soviet specialists consider that this will facilitate a more effective solution to the ASW problem.

A short description of the SOSUS system's role in determining the position of the Skorpion sinking is given.

Undersea monitoring is also performed using highly selective acoustic systems capable of detecting the signal of a sub against background noise from a number of ocean sources. This is achieved through matched summing of signals received by hundreds and even thousands of scattered hydrophones. These hydrophones are moored at various depths or are installed as a two-dimensional antenna array several hundred meters long. In both cases, they connect to a shore-based computer which sums all the signals with input of the corresponding time delay for each hydrophone individually. If a focused antenna system is used, the computer shapes a narrow beam by integrating the

antenna hydrophone signals after input of the corresponding time delay at the output of each hydrophone. Thus the computer simultaneously shapes several beams which "comb" the ocean.

To determine target position based on its acoustic field (Caesar system), on the reflection of energy from powerful, low-frequency emitters (Artemis system), or on explosive sound sources, several receiving units, grouped in pairs, are used. The time difference in the arrival of the sound signal at each pair of receivers is measured, which corresponds to their distances to the sound source. The intersect determines the position of the sound source.

In conjunction with the Caesar system development program begun in the '50's, the US Navy has installed a network of detection hydrophones on the continental shelf along the eastern coast of the continent and on rises in the World Ocean. The Caesar system has been improved and its coverage now includes the Caribbean and the Gulf of Mexico.

A similar system was developed in the mid '60's along the west coast of the US. In this system, the hydrophones are mounted on towers installed on the bottom. According to the non-Soviet press, stationary long-range detection equipment has also been installed along the Aleutian Islands and Kurile Basin chain. Press reports have appeared of similar systems, "Barrier" and "Bronco" which have been installed along the coasts of England, Portugal, Denmark, Italy, and Turkey.

Caesar system data is received by 21 shore-based information processing centers.

At the end of 1969, a first attempt was made at deploying a 3-m-diameter hydrophone-equipped casing at 4900 m north of the Hawaian Islands. This effort was unsuccessful. In 1973, the "Sea Spider" Hawaiian surveillance network became operational. According to American sources, the installation of these detectors called for the solution of very complicated problems due to the extreme depths in this area.

Another detection system developed by the US Navy and other NATO nations is the AFAR system, which was put into operation north of the Azores. It consists of hydrophone-equipped 130-meter-high towers secured on the bottom. Three towers form a triangle 35 km on a side. Reports indicate that AFAR provides submarine surveillance at the approaches to the Strait of Gibraltar. The detection systems use the American AN/FQQ-1, AN/FQQ-8, and AN/FQQ-10 hydrophones. Target fixing is accomplished by triangulation.

To organize surveillance along ASW lines, the combined use of fixed and positionable systems with mobile forces has been proposed. Non-Soviet specialists suggest that the effectiveness of surveillance lines can be improved by wider use of self-contained automatic systems deployed from aircraft or submarines.

The US is presently developing a moored hydroacoustic submarine detection system (MSS), representing a cross between the Caesar fixed antenna array and expendable air-dropped sonobuoys. Radio-telemetering sonar buoys about the size of a torpedo are air dropped, are automatically moored at a predetermined depth, and transmit information via satellite or aircraft. The operating life of these buoys is 90 days, and they operate at depths to 4900 - 5500 m. The buoys are equipped with recorders to gather information on underwater targets. Either upon interrogation or independently, this information is relayed by radio, using a high-speed transmission device to reduce the possibility of position-finding by an enemy.

The SAS fixed system is also being developed. In this system, the detectors will be mounted on high tripods deployed at depths of 5000 m, 10 km apart.

In 1972, the US committee on budget appropriations approved a plan for improving the existing lines of areas at the far approaches to the coast and straits, and the establishment of new lines. A large amount of money is being spent for these purposes. For example, out of $327 million intended to supplement ASW programs, in 1975 almost 25% (roughly $80 million)

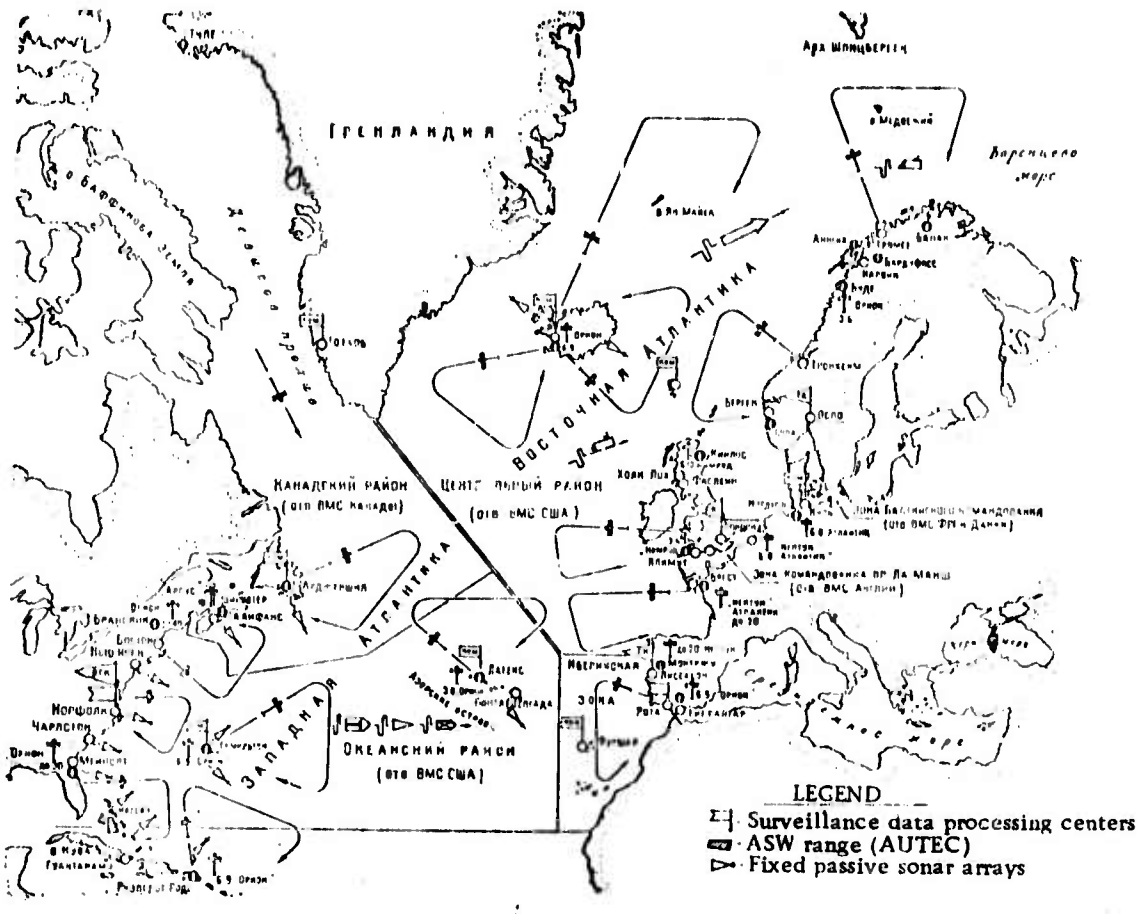

Fig. 2. Organization of Continuous ASW Surveillance in the Atlantic.

[Note: Many of the conventions used on this map are not explained. Points where "Orion", "Neptune", "Nimrod", or "Atlantic" type aircraft are stationed are indicated by ●, and symbol ⊣ with small numbers indicates the number of such aircraft, e.g. Hamilton (Bermuda) - 6 to 9 "Orions"].

will be spent on the development of a global system for long-range hydroacoustic surveillance.

Research is continuing on the expansion of operating areas of fixed systems near the Aleutian Islands, Taiwan, Okinawa, Korea, and the Philippine Islands. In the Hawaiian Islands, a joint intelligence [reconnaissance?] center for the SOSUS system is being established.

Presently, the main underwater environment surveillance data processing center [ASWEPS?] is in Suitland, while fleet centers are located in Norfolk, San Francisco, London, and Rota. The American naval command places great importance on the fact that, following analysis and processing at shore-based centers, information gathered by all underwater surveillance sources (SOSUS) is rapidly disseminated to ASW forces. One of the measures taken to solve this problem was the development of a specialized information system (OSIS) consisting of shore-based centers for processing and transmitting information to ships and aircraft in the field. As SOSUS is improved and its areas of coverage expanded, the Pentagon intends to establish an integrated and continuously operating system of underwater hydroacoustic surveillance with global control by US armed forces, with 35 computer centers and highly developed communications.

Recent Publications on Hydroacoustics

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Orlov, L. V. and A. A. Shabrov. Raschet i proyektirovaniye antenn gidroakusticheskikh rybopoiskovykh stantsiy (Calculation and design of antennas for hydroacoustic fish finders). Moskva, Pishchevaya prom-st', 1974, 275 p.

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